 Faculty and Researcher Publications

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Team 4: Evaluation of Electro-optical Sensor Systems in Network Centric Operations using ABSEM 0.5

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TEAM 4 MEMBERS

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INTRODUCTION

During the last few years, on behalf of the Bundeswehr, the Bundeswehr Procurement Office, and the Bundeswehr Centre for Transformation, Cassidian (formerly EADS) has been working on the development of two agent-based simulation models: First, the model PAX, that concentrates on studying peace support operations and focuses on analyzing aggression emergence within civilian groups. Secondly, the model ABSEM, which is an agent-based model that concentrates on modeling complex technical systems with a detailed physical approach and thus allowing to analyze the combination of various sensor and effector systems in NCO.

At IDFW 21, the main focus was to analyze sensor systems and different tactics, techniques and procedures (TTP) in NCO.

One military scenario was modeled, which focused on questions in the context of convoy protection. Different realistic asymmetric threat situations were simulated and different action alternatives with variable TTPs were analyzed and compared to each other.

Figure 1: TIGER HELICOPTER

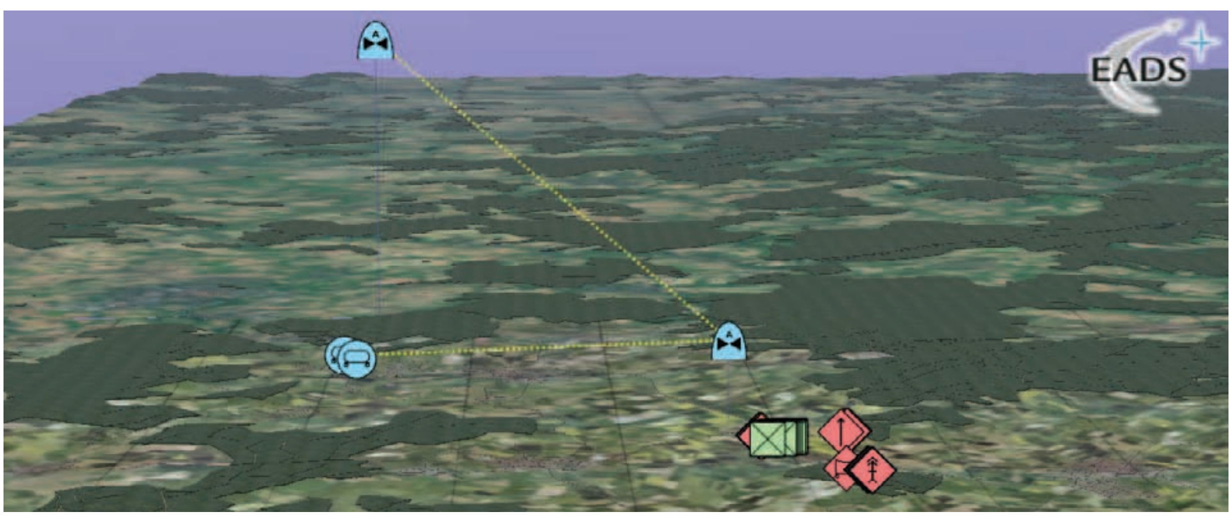

Figure 2: Convoy ambush scenario

Scenario Description

A Convoy consisting of transport trucks and an armored infantry platoon moves on a main line of communication. An alternative route has been reconnoitered. 2 TIGER helicopters are deployed for convoy protection using the ground escort technique.

Insurgents (INS) prepared an ambush along the LoC with two INS groups hidden on both sides of the road. The INS are equipped with sub-machine guns and RPGs. A third INS group with pickup trucks is hiding about 3 km away from the ambush. This group is also equipped with mortars mounted on pickup trucks to support the other INS groups with indirect fire.

If the convoy or the helicopters identify the ambush situation, the convoy will use the alternative route and avoid the ambush.

Data Farming Questions and Parameters

The main analysis question to explore was how the flight pattern of the two helicopters would effect the identification of INS.

To answer this question simulation parameters of the own troops (BLUE) and the INS (RED) were varied.

It was important to ensure that only input data was changed, which was meaningful to the simulation scenario and needed to answer the data farming question.

To compare data farming results two measures of effectiveness (MoE) were defined:

a. MoE 1: Distance of first convoy vehicle to INS 1 when on TIGER identifies the first INS

b. MoE 2: Proportion of identified INS by both TIGERS at the end of the simulation (convoy reaches intersection with the alternative route)

BLUE Farming Parameters	Min	Max
Difference of TIGER speed to convoy speed (km/h)	20	100
Helicopter height above ground (m)	200	1600
First helicopter distance to convoy (m)	0	6000
Convoy speed (km/h)	20	50

Table 1: BLUE Farming Parameters

RED Farming Parameters	Min	Max
Number of INS in each group	10	40
INS camouflage level	0	100

Table 2: RED Farming Parameters

Analysis

The team used a two prong approach to farm data:

a. Despite only having 6 input parameters we used an NOLH design with 65 unique trials. This design was chosen to a high density of data points within the design space.

   At each design points we ran 100 replications.

b. Use a fully gridded design to compute results for a validation data set.

The simulation results were divided into two data sets to analyze both MoE's independently. During the workshop we were only able to analyze the data set for MoE 2.

In a first step we checked the input data to make sure that we did not make any mistakes in the experiment setup. The following figure shows an example for the distribution of input data for relative TIGER speed.

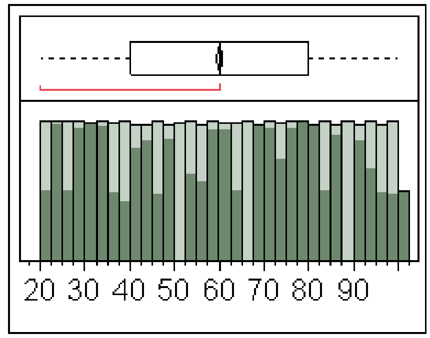

Figure 3: Distribution of input data for relative Tiger speed

In the next step we built a regression model based on the results of the NOLH design to forecast results and to easily show dependencies. We started by using partition trees to identify the main contributing factors. Figure 4 shows the main factors after 31 splits.

Column Contributions

Term	Number of Splits	SS
TigerSpeedRelative	3	0.41802371
TigerHeight	8	12.8738769
Tiger1_Distance	2	0.14791312
ConvoySpeed	4	3.1968188
num_INS2_AK47	7	0.81823484
InsurgentCamouflage	7	908.650834
Total	31	926.105701

Figure 4: Main contributing factors

Because the INS camouflage level contibuted more , by far, than any other factor we computed another decision tree, eliminating the influence of INS factors (Figure 5).

Column Contributions

Term	Number of Splits	SS
TigerSpeedRelative	7	448.820034
TigerHeight	3	226.622811
Tiger1_Distance	3	178.174225
ConvoySpeed	1	35.2415044
num_INS2_AK47	0	0
InsurgentCamouflage	0	0
Total	14	888.858574

Figure 5: Main BLUE contributing factors

From both results we could identify the following factors as contributing to our regression model:

a. INS camouflage level

b. Relative TIGER speed

c. TIGER height above ground

d. TIGER distance to convoy

e. Number of INS

To build the model we used a stepwise regression with those factors and only kept terms in the model that improved R2. We chose to build a quadratic model with two term interactions.

The prediction profiler shows how changes in one of the factors, in this case the INS camouflage level, change the influence of the other factors.

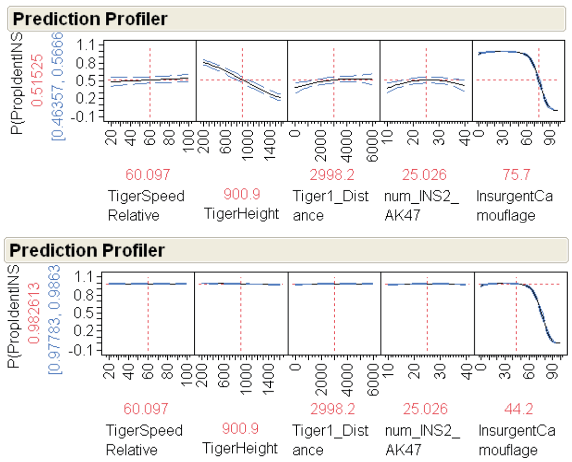

Figure 6: Prediction profiler for the regression model

We validated the regression model with the validation data set and could show that it provides reasonable predictions.

RESULTS

We were able to build a regression model, to validate it using an independent data set and to show that all factors in the model were significant.

The main findings are that our tactics, techniques and procedures only make a difference when the insurgents are well camouflaged. Otherwise the well advanced TIGER sensor can identify them independently from its flight pattern.

For well camouflaged INS we identified the helicopter elevation above ground as the most important factor. A lower flight elevation leads to a greater possibility of enemy detection. This factor is so important in the model because it shows up as a quadratic term and in many tow way interactions with other contributing factors.

Further important factors are relative TIGER speed, distance of the TIGER to the convoy, and the convoy speed.

CONCLUSIONS

For team 4 this was a very successful workshop since we were able to set up a complex scenario in ABSEM and to conduct multiple simulation runs on our computer cluster using as well NOLH as fully gridded designs. The analysis let to the identification of main factors in a convoy protection scenario. This allows us to focus future live exercises on main TTPs for convoy protection using helicopters.

Authors

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[4] Software Downloads, SEED Center for Data Farming, http://harvest.nps.edu/

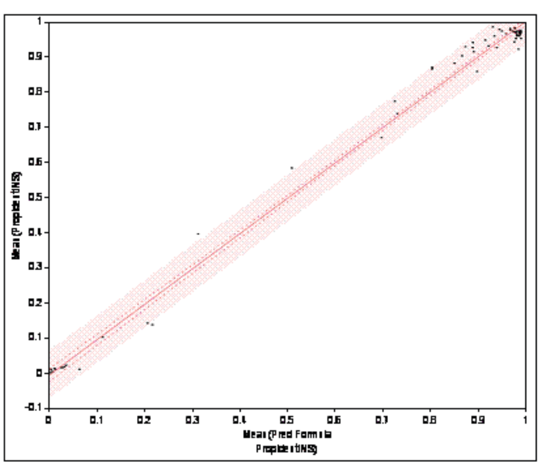

Figure 7: Fitting the model

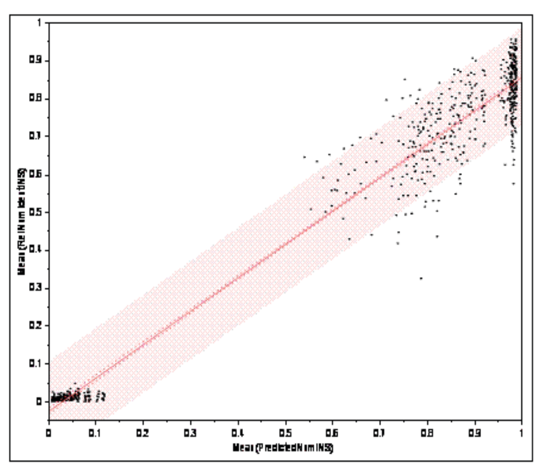

Figure 8: Validating the model